IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of:	)	
	)	
Jean-Michel Rouet et al.	)	
	)	
Serial No.: 10/542,122	)	Group Art Unit: 2628
	)	
Filed: July 12, 2005	)	Examiner: Peter Pappas
	)	
For: IMAGE PROCESSING METHOD FOR AUTOMATIC ADAPTATION OF 3-D DEFORMABLE MODEL ONTO A SUBSTANTIALLY TUBULAR SURFACE OF A 3-D OBJECT	)	**Board of Patent Appeals and Interferences**
	)	
Confirmation No.: 8397	)	

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APPEAL BRIEF UNDER 37 C.F.R. § 41.37

In support of the notice of appeal filed on October 22, 2009, and pursuant to 37 C.F.R. § 41.37, Appellants present this Appeal Brief in the above-captioned application.

This is an appeal to the Board of Patent Appeals and Interferences from the Examiner's final rejection of claims 1-11 and 13-17 in the Final Office Action dated July 21, 2009. The appealed claims are set forth in the attached Claims Appendix.

1. Real Party in Interest

This application is assigned to Koninklijke Philips Electronics N.V., the real party in interest.

2. Related Appeals and Interferences

There are no other appeals or interferences that would directly affect, be directly affected, or have a bearing on the instant appeal.

3. Status of the Claims

Claims 1-11 and 13-17 have been rejected in the Final Office Action. Claim 12 has been cancelled. The final rejection of claims 1-11 and 13-17 is being appealed.

4. Status of Amendments

All amendments submitted by Appellants have been entered.

5. Summary of Claimed Subject Matter

The present invention, as recited in independent claim 1, relates to an image data processing method of automatic adaptation of a 3-D surface model to image features for model-based image segmentation. (See Specification, ¶ [0003]). The method includes creating a deformable tubular mesh model for fitting a 3-D path based on a centerline of a 3-D tubular object of interest. (See Id., ¶¶ [0004], [0040], Fig. 1). The 3-D path includes a set of ordered points defining a plurality of path segments. (See Id.). The mesh model has an initial radius and includes a plurality of mesh segments corresponding to the plurality of path segments.(See Id., ¶ [0004], Fig. 3B). The method further includes automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor. (See Id., ¶ [0057], Fig. 6B). The

shrinking factor is determined based on the initial radius and a radius of local curvature of the corresponding path segment. (See Id.).

The present invention, as recited in independent claim 10, relates to a medical viewing system including means (151) for acquiring 3-D medical image data of a 3-D object of interest having substantially tubular parts. (See Id., ¶¶ [0026], [0070], Fig. 9). The system also includes a suitably programmed computer or a special purpose processor (153) having circuit means arranged to process the image data according to the method as claimed in claim 1. (See Id., ¶ [0070]). The system includes display means (154) to display the medical images. (See Id.).

The present invention, as recited in independent claim 14, relates to a method of automatically adapting a three-dimensional surface model of a substantially tubular object. (See Specification, ¶ [0003]). The method includes determining a three-dimensional path corresponding to a centerline of the tubular object and defining a plurality of path segments on the three-dimensional path. (See Id., ¶¶ [0004], [0040], Fig. 1). The method further includes creating an initial straight deformable cylindrical mesh model having a length equal to a length of the three-dimensional path. (See Id., ¶¶ [0004], [0031], [0042], Fig. 1). The method further includes dividing the initial mesh model into a plurality of mesh segments corresponding to the plurality path segments. (See Id., ¶¶ [0004], [0043], Fig. 3B). The method further includes computing a rigid-body transformation for each mesh segment for transforming an initial direction of each mesh segment into a path direction of the corresponding path segment. (See Id., ¶ [0044], Fig. 4B). The method further includes applying the rigid-body transformation for each mesh segment to corresponding vertices of the mesh segment. (See Id.). The method further includes adapting a mesh radius of each mesh segment based on a product of an initial radius of the initial mesh model and a shrinking factor. (See Id., ¶ [0057, Fig. 6B). The shrinking factor is determined based on at least a radius of curvature and a length of the corresponding path segment. (See Id.).

The present invention, as recited in independent claim 17, relates to a computer readable medium for storing a computer program executable to process data for automatic adaptation of a three-dimensional surface model to image features. (See Id., ¶ [0070]). The computer readable medium includes a mesh model code segment for creating a deformable tubular mesh model for fitting a three-dimensional path based on a centerline of a 3-D tubular object of interest. (See Id., ¶¶ [0004], [0040], Fig. 1). The three-dimensional path includes a set of ordered points defining a plurality of path segments. (See Id.). The mesh model has an initial radius and includes a plurality of mesh segments corresponding to the plurality of path segments. (See Id., ¶ [0043]). The computer readable medium also includes a radius adapting code segment for automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor. (See Id., ¶ [0057, Fig. 6B). The shrinking factor is determined based on a radius of local curvature of the corresponding path segment and the initial radius. (See Id.).

6. Grounds of Rejection to be Reviewed on Appeal

I. Whether claims 1-3, 6, 10, 11, 13, and 17 are unpatentable under 35 U.S.C. § 103(a) over Florez-Valencia et al., "3D Graphical Models for Vascular-Stent Pose Simulation" (hereinafter "Florez") in view of Dumoulin, et al., "Mechanical Behaviour Modelling of Balloon-Expandable Stents" (hereinafter "Dumoulin") in view of Hernandez-Hoyos et al., "Computer-assisted Analysis of Three-Dimensional MR Angiograms" (hereinafter "Hernandez"), in view of Montagnat et al., "A Hybrid Framework for Surface Registration and Deformable Models" (hereinafter "Montagnat"), and further in view of Yim et al., "Vessel Surface Reconstruction With a Tubular Deformable Model" (hereinafter "Yim").

II. Whether claims 4, 5, 7-9, and 14-16 are unpatentable under 35 U.S.C. §103(a) over Florez, Dumoulin, Hernandez, Montagnat, Yim, and further in view of Williams et al., "Rational Discrete Generalized Cylinders and their Application to Shape Recovery in Medical Images" (hereinafter "Williams").

7. Argument

1. The Rejection of Claims 1-3, 6, 10, 11, 13, and 17 Under 35 U.S.C. § 103(a) Should Be Reversed.

A. The Examiner's Rejection

In the Final Office Action, the Examiner rejected claims 1-3, 6, 10, 11, 13, and 17 under 35 U.S.C. § 103(a) as unpatentable over Florez, Dumoulin, Hernandez, Montagnat, and Yim. (See 7/21/09 Office Action, pp. 2-9).

In the Final Office Action, the Examiner states that Florez teaches automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor. Specifically, the Examiner states that Florez's disclosure that Maracas roughly estimates a set of radii meets the recitation of automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor. (See Id., p. 2). To supplement the teachings of Florez, the Examiner states that Florez relies on the teachings of Dumoulin, Hernandez, Montagnat, And Yim. (See Id. p. 4). The Examiner specifically refers to Yim and asserts that Yim discloses automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on the initial radius and a radius of local curvature of the corresponding path segment. (See Id., pp. 4-5). Specifically, the Examiner refers to the warping, or amount of truncation, in areas where vessel axes are curved, as disclosed by Yim, to meet the claimed shrinking factor. (See Id., p. 4). The Examiner also states that the claims fail to disclose exactly what constitutes "a product of" and "a shrinking factor" as recited in the claims and interprets "a product of" to mean in "consideration of." (See Id).

B. Florez, Dumoulin, Hernandez, Montagnat, And Yim Do Not Disclose Or Suggest Automatically Adapting A Length Of A Mesh Radius Of Each Mesh Segment Based On A Product Of The Initial Radius And A Shrinking Factor, The Shrinking Factor Determined Based On The Initial Radius And A Radius Of Local Curvature Of The Corresponding Path Segment

Claim 1 recites "[a]n image data processing method of automatic adaptation of 3-D surface Model to image features, for Model-based image segmentation, the method comprising: creating a deformable tubular mesh model for fitting a 3-D path based on a centerline of a 3-D tubular object of interest, the 3-D path comprising a set of ordered points defining a plurality of path segments, the mesh model having an initial radius and comprising a plurality of mesh segments corresponding to the plurality of path segments; and automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on the initial radius and a radius of local curvature of the corresponding path segment."

Yim describes a coordinate system that warps radial lines in areas where the vessel axis is curved in order to prevent radial lines from intersecting one another. (See Yim, p. 1414, col. 1, ¶ 2.) Radial lines intersect one another if one radial line enters the territory of another; a radial line's territory is defined as the region that is closer to the origin of that radial line than to the origin of any other radial line. (See Id., p. 1414, col. 1, ¶ 3.) Thus, intersections can be prevented by confining each radial line to its own territory. (See Id., p. 1414, col. 1, ¶ 3.) Each radial line is thus truncated at the point at which it leaves its own territory. (See Id., p. 1415, col., 1, ¶ 1.) However, Yim does not disclose or suggest that the mesh radius is adapted "based on a product of the initial radius and a shrinking factor," or that "the shrinking factor [is] determined based on the initial radius and a radius of local curvature of the corresponding path segment," as recited in claim 1.

The Examiner seeks to cure the deficiencies of Yim by referring back to Florez and asserting that Florez discloses automatically adapting a length of a mesh radius of each mesh segment based on the corresponding path segment and the initial radius. (See 7/21/09 Office Action, pp. 12-13). Florez discloses a geometrical model using a generalized cylinder to represent a vessel. Florez also discloses that simplex meshes "are discrete representations of surfaces suited to deformation." (See Florez, p. 3,

§ 3, ¶ 1). To define the local deformation for each surface vertex, Florez discloses an equation (equation 1). However, Florez explains that this equation "does not take into account the particular shape and expected properties of the modeled object." (See Id., § 3.2, ¶ 1). Deformations should preserve the generalized cylindrical shape of the vessels. (See Id.). According to Florez, "[w]hen the model surface undergoes some deformation, the centerline bends accordingly through an external force resulting from the surface forces." (See Id., ¶ 2). So, the bending that Florez discusses is not analogous to the "radius of local curvature of the corresponding path segment" recited in claim 1 because the curvature of a path segment clearly relates to the natural orientation of the tubular mesh whereas the bending discussed by Florez is bending due to an external force. (See Id.). This is further supported by Florez's disclosure that "[d]eformable models are sensitive to their initialization as they usually converge towards a local minimum of their energy functional." (See Id., § 3.3, ¶ 1). That is, the deformable models return to their original state after being deformed by an external force (for example, a stretched rubber band that returns to its original shape when the stretching force is stopped). It seems the Examiner uses the disclosure by Florez regarding "initialization," in addition to Florez's calculation of centerline points (a_i) and a set of radii (r_i) to provide the "initialization," to meet the recited initial radius. However, claim 1 recites "automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on the initial radius and a radius of local curvature of the corresponding path segment." As previously stated, Florez does not adapt a length of the mesh radius based on a product of the initial radius and a shrinking factor, but rather on an external force acting upon the surface of the vessel.

In response to the Examiner's contention that the claim language fails to disclose exactly what constitutes "a product of" and "a shrinking factor," Appellants remind the Examiner that a claim is read in view of the specification. Therefore, in view of the specification, one of ordinary skill in the art reading the claim would understand that "a product of" means the result of multiplying and that "a shrinking factor" is a defined constant. (See Specification, ¶ [0058]).

Appellants respectfully submit that none of Dumoulin, Hernandez, nor Montagnat cure the deficiencies of Florez and Yim and that Florez, Dumoulin, Hernandez, Montagnat, and Yim, taken alone or in any combination, fail to disclose or suggest ""automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on the initial radius and a radius of local curvature of the corresponding path segment," as recited in claim 1. It is, therefore, respectfully submitted that claim 1 and its dependent claims 2-3, 6, and 13 are allowable.

Appellants respectfully submit that independent claim 10 includes all of the limitations of claim 1. Thus, it is respectfully submitted that claim 10 and its dependent claim 11 are also allowable for at least the foregoing reasons presented with regard to claim 1.

Claim 17 recites "a radius adapting code segment for automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on a radius of local curvature of the corresponding path segment and the initial radius." Therefore, Appellants respectfully submit that claim 17 is also allowable for at least the foregoing reasons presented with regard to claim 1.

III. The Rejection of Claims 4, 5, 7-9, and 14-16 Under 35 U.S.C. § 103(a) Should Be Reversed.

A. <u>The Examiner's Rejection</u>

In the Final Office Action, the Examiner rejected claims 4, 5, 7-9, and 14-16 under 35 U.S.C. § 103(a) as unpatentable over Florez, Dumoulin, Hernandez, Montagnat, Yim, and Williams. (<u>See</u> 7/21/09 Office Action, pp. 9-11).

The Examiner seeks to cure the deficiencies of Florez, Dumoulin, Hernandez, Montagnat, and Yim by referring to Williams. (See 7/21/09 Office Action, p. 9).

B. Florez, Dumoulin, Hernandez, Montagnat, Yim, And Williams Do Not Disclose Or Suggest Automatically Adapting A Length Of A Mesh Radius Of Each Mesh Segment Based On A Product Of The Initial Radius And A Shrinking Factor, The Shrinking Factor Determined Based On The Initial Radius And A Radius Of Local Curvature Of The Corresponding Path Segment

Appellants respectfully submit that Williams fails to cure the above mentioned deficiencies of Florez and Yim and that Florez, Dumoulin, Hernandez, Montagnat, Yim, and Williams, taken alone or in any combination, fail to disclose or suggest "automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on the initial radius and a radius of local curvature of the corresponding path segment," as recited in claim 1. Because claims 4, 5, and 7-9 depend from and, therefore, include all of the limitations of claim 1, it is respectfully submitted that these claims are allowable.

Claim 14 recites "adapting a mesh radius of each mesh segment based on a product of an initial radius of the initial mesh model and a shrinking factor, the shrinking factor being determined based on at least a radius of curvature and a length of the corresponding path segment." Therefore, it is respectfully submitted that claim 14 and its dependent claims 15-16 are also allowable for at least the above-mentioned reasons presented with regards to claim 1.

8. Conclusion

For the reasons set forth above, Appellants respectfully request that the Board reverse the rejection of the claims by the Examiner under 35 U.S.C. § 103(a), and indicate that claims 1-11 and 13-17 are allowable.

Respectfully submitted,

Date: December 7, 2009

By: ____________________

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CLAIMS APPENDIX

1. (Previously Presented) An image data processing method of automatic adaptation of 3-D surface Model to image features, for Model-based image segmentation, the method comprising:

creating a deformable tubular mesh model for fitting a 3-D path based on a centerline of a 3-D tubular object of interest, the 3-D path comprising a set of ordered points defining a plurality of path segments, the mesh model having an initial radius and comprising a plurality of mesh segments corresponding to the plurality of path segments; and

automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on the initial radius and a radius of local curvature of the corresponding path segment.

2. (Previously presented) The image proeessing method of claim 1, wherein creating the deformable tubular mesh model comprises:

creating a tubular structure for fitting the 3-D path; and

mapping the tubular structure onto a 3-D surface of the tubular object of interest, which is represented in a gray level 3-D image.

3. (Previously presented) The image processing method of claim 1, further comprising:

computing the 3-D path that corresponds to the centerline of a the tubular object of interest and defining the path segments on the 3-D path;

creating an initial straight deformable cylindrical mesh model, of any kind of mesh, having a length along a longitudinal axis equal to a length of the 3-D path;

dividing the initial mesh model into segments of length corresponding to the path segments of the 3-D path; and

computing, for each mesh segment of the initial mesh model, a rigid-body transformation that transforms an initial direction of the mesh segment into a direction of the corresponding path segment of the 3-D path, and applying the transformation to corresponding vertices of the mesh segment.

4. (Previously presented) The image processing method of claim 3, further comprising:

blending the rigid-body transformations of consecutive mesh segments.

5. (Previously presented) The image processing method of claim 4, further comprising:

computing rotations for the rigid-body transformations of consecutive mesh segments,

wherein a linear interpolation is used between rotations of the consecutive mesh segments for blending the 3-D rigid body transformations to limit self-intersections between bent portions of the deformable tubular mesh model.

6. (Previously presented) The image processing method of claim 1, wherein automatically adapting a mesh radius comprises:

modulating the initial radius of the deformable tubular mesh model according to a local curvature of the 3-D path to limit self-intersections between bent portions of the deformable tubular mesh model.

7. (Previously presented) The image processing method of claim 6, further comprising:

approximating the local curvature; and

applying a radius modulation technique comprising one of linear blending or bi-cubic spline interpolation from one radius to another.

8. (Previously presented) The image processing method of claim 1, further comprising:

determining a 3-D rotation comprising computing a minimal 3-D rotation from an initial mesh direction to a target segment to minimize mesh torsion.

9. (Previously presented) The image processing method of claim 8, wherein determining the 3-D rotation further comprises:

defining rotation between segments using an axis parameter and a rotation angle parameter; and

computing the parameters iteratively between adjacent segments so that a new rotation for a current segment comprises a composition of a found rotation for a previous segment and the minimal rotation from the previous segment to the current segment.

10. (Previously presented) A medical viewing system comprising:

means for acquiring 3-D medical image data of a 3-D object of interest having substantially tubular parts;

a suitably programmed computer or a special purpose processor having circuit means arranged to process the image data according to the method as claimed in claim 1; and

display means to display the medical images.

11. (Previously presented) A medical examination apparatus comprising:

means to acquire a three-dimensional image of an organ of a body, the organ having substantially tubular parts; and

a medical viewing system according to claim 10.

12. (Cancelled)

13. (Previously presented) The image processing method of claim 2, wherein the deformable tubular model is created with one of 2-simplex meshes or triangular meshes.

14. (Previously presented) A method of automatically adapting a three-dimensional surface model of a substantially tubular object, the method comprising:

determining a three-dimensional path corresponding to a centerline of the tubular object;

defining a plurality of path segments on the three-dimensional path;

creating an initial straight deformable cylindrical mesh model having a length equal to a length of the three-dimensional path;

dividing the initial mesh model into a plurality of mesh segments corresponding to the plurality path segments;

computing a rigid-body transformation for each mesh segment for transforming an initial direction of each mesh segment into a path direction of the corresponding path segment;

applying the rigid-body transformation for each mesh segment to corresponding vertices of the mesh segment; and

adapting a mesh radius of each mesh segment based on a product of an initial radius of the initial mesh model and a shrinking factor, the shrinking factor being determined based on at least a radius of curvature and a length of the corresponding path segment.

15. (Previously presented) The method of claim 14, further comprising:

performing linear blending on the rigid-body transformations of consecutive mesh segments.

16. (Previously presented) The method of claim 14, wherein adapting the mesh radius of each mesh segment comprises reducing a diameter of the deformable cylindrical mesh model in highly curved portions of the three-dimensional path.

17. (Previously Presented) A computer readable medium for storing a computer program executable to process data for automatic adaptation of a three-dimensional surface model to image features, the computer readable medium comprising:

a mesh model code segment for creating a deformable tubular mesh model for fitting a three-dimensional path based on a centerline of a 3-D tubular object of interest, the three-dimensional path comprising a set of ordered points defining a plurality of path segments, the mesh model having an initial radius and comprising a plurality of mesh segments corresponding to the plurality of path segments; and

a radius adapting code segment for automatically adapting a length of a mesh radius of each mesh segment based on a product of the initial radius and a shrinking factor, the shrinking factor determined based on a radius of local curvature of the corresponding path segment and the initial radius.

EVIDENCE APPENDIX

No evidence has been submitted herewith or is relied upon in the present appeal.

RELATED PROCEEDINGS APPENDIX

No decisions have been rendered regarding the present appeal or any proceedings related thereto.